Neurodevelopmental Approach to Breastfeeding the Neonate

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Cape Town, South Africa

www.skintoskincontact.com

“needed neural processes”

“except in the light of mother’s body.”

“buffering protection of adult support”

ZERO SEPARATION
There are “needed neural processes”!

... these data indicate that pups have a unique learning circuit relying on the olfactory bulb for neural plasticity and on the hyperfunctioning noradrenergic locus coeruleus flooding the olfactory bulb with norepinephrine to support the neural changes.
Simulated birth (rat)

**The Experience of Being Born: A Natural Context for Learning to Suckle**

Jeffrey R. Alberts† and April E. Reinecke

The first hours after birth are a CRITICAL PERIOD

Those babies showing the greatest increase in [Hb O2] were between 6 and 24 h old at testing.

In the 14 babies older than 24 h, there was no significant difference between the changes in [Hb O2] during control and colostrum exposure.

Simulated birth (rat)

**DOUCET**

The secretion of Areolar (Montgomery’s) Glands from Lactating Women Elicits Selective, Unconditional Responses in Neonates

"... breast chemosignals activate oral activity on the nipple that releases a cascade of behavioral, neural, neuroendocrine and endocrine processes in the newborn and the mother."

Doucet 2009

Simulated birth (rat)

**DOUCET**

The secretion of Areolar (Montgomery’s) Glands

"In early ontogeny the sleeping brain may thus remain sentient of an organism’s odor environment."

Doucet 2009

In the “scentless breast” condition, all infants were exposed to the mother’s breast fully covered with a perfectly transparent and airtight plastic film (polypropylene). (the habitual visual scene of the breast devoid of corresponding odors)

Less AG → delayed grasp
Less AG → Slower latch
Less AG → Weaker suck
Less AG → More weight loss day 3 of life
Less AG → Delayed onset of lactation

Difference $p < 0.001$

Primest high AG: 2.3 days
Primest low AG: 3.1 days

Figure 1: Distribution of average scores of maternal perception of infants’ (A) rooting duration, (B) nipple grasping speed, and (C) sucking intensity as a function of mothers’ areolar gland numbers ($n=17$ mother-infant dyads).

The “Smellscape” of Mother’s Breast: Effects of Odor Masking and Selective Unmasking on Neonatal Arousal, Oral, and Visual Responses

(1) “Breast” group (fully uncovered mother’s breast); (2) “Nipple” group (all remaining parts covered with plastic film); (3) “Areola” group (remainder of the breast and nipple covered); (4) “Milk” group (milk smeared on plastic covered breast)
…only male newborns opened their eyes longer in response to odorous breast conditions than to the scentless condition (0.654 vs. 0.425; p<.01).

They displayed significantly longer global oral activity when facing any of the odorous breast with opened eyes, the three other conditions being equivalent:

- Odorous breast/opened eyes: 13.27
- Odorous breast/closed eyes: 9.92
- Scentless breast/opened eyes: 6.63
- Scentless breast/closed eyes: 8.39

Related experiments indicate, however, that the chemical cues that attract rat pups to the nipples are not produced in that region. Rather, initial nipple orientation is elicited by the odor of amniotic fluid and saliva that the mother spreads on her ventrum while grooming herself during parturition [7].

Babies more often spontaneously selected a breast treated with a small amount of their own AF applied to the nipple/areola region, than the alternative untreated breast, during tests beginning several minutes after parturition [112].

These results are corroborated by a study in which 2-day old infants were offered a simultaneous choice between two gauze pads; the length of time oriented to the odor of their AF was reliably greater than that towards an odorless stimulus pad [92].

PSN envisions a community that embraces its mothers and babies, and values the unique opportunity at birth to impact the physical and emotional well-being of the newborn.

Target #1 for 2005:

Report that 65% of infants are placed and remain in direct skin to skin contact with their mothers for at least one hour during the first 3 hours after birth.
More skin-to-skin $\rightarrow$ more breastfeeding

Babies breastfeeding
Mothers intending to breastfeed

Journal of Human Lactation

Effect of Early Skin-to-Skin Mother-Infant Contact During the First 2 Hours Following Birth on Exclusive Breastfeeding During the Acuteness Hospital Stay

Table 4: Breastfeeding Outcome

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control Group</th>
<th>Early-Contact Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breastfeeding at discharge</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Breastfeeding at two months</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Partial or not all 'successful'</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 5: Postpartum Observations in Delivery Room

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control Group</th>
<th>Early-Contact Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin-to-skin contact</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Attempted breastfeeding</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Infant sucked</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Happy maternal reaction to infant</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

Thomson 1979

Saliary 1978

Infant Feeding

E Early SSC first hour
L Late contact next day
2 2 hourly feeds from birth
4 4 hourly feeds from birth

Group  Brf at 12 w  Brf duration (days)
2E 64.3%  182 (14 - 392)
4E 55.6%  140 (14 - 322)
2L 55.6%  112 (10 - 294)
4L 46.2%  77 (11 - 280)
The Neuroscience of Birth & Breastfeeding

Breastfeeding behavior
Breastfeeding WIRING

Wire Mother

Early life modifications for infants and their mothers: evidence links (Review)

The DNA
EPIGENETICS

The Brain
NEURODEVELOPMENT

Behaviour
EVOLUTIONARY BIOLOGY

Environment
ADAPTATION

Reproductive fitness
SEPARATION

Birth
BONDING

Beyond
Sensitization

Secure attachment
Attuned parenting

Oxytocin
OXYTOCIN comes from cervical dilatation, breastfeeding, skin-to-skin contact, and eye-to-eye contact.

Effects of doula care:

<table>
<thead>
<tr>
<th>USA (Kennell et al. 1991)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No doula</td>
</tr>
<tr>
<td>Doula</td>
</tr>
<tr>
<td>Epidural</td>
</tr>
<tr>
<td>Caesarean section</td>
</tr>
<tr>
<td>Forceps delivery</td>
</tr>
<tr>
<td>Fetal distress</td>
</tr>
</tbody>
</table>

“If a Doula was a drug, it would be unethical not to use it”

Dr. John Kennell

Marshall Klaus & John Kennell

1922 - 2013

EARLY CHILDHOOD DEVELOPMENT (ECD)

“First 1000 days” =
- gestation 270
- year one 365
- year two 365
- total 1000 days

DOULA - “A WOMAN SERVING WOMEN” BIRTH SUPPORT COMPANION

KANGAROO CARE & DOULA = “KANGAROULA”

“First 1000 days” =
- First 1000 sec = 16 minutes = 1st hour
- First 1000 min = 16.6 hours = 1st day
- First 1000 hrs = 1st six weeks
DOULA and KANGAROULA

DOULA protects OXYTOCIN during labour.

KANGAROULA protects OXYTOCIN after birth.

The first 1000 minutes

BIRTH

OXYTOCIN

-1000 min +1000 min 1000 days

CORTISOL → Enemy of oxytocin
Stress

During the first 24 hours of life, newborns ingested 15 g of milk.
"The newborn may appear helpless, but skin-to-skin contact stimulates prolactin ensuring nutrition, oxytocin ensuring protection, and cholecystokinin ensuring well-being bonding.

The first hours after birth are a critical period, mutual psycho-neuro-physiological caregivers.

Critical period concept:

"Windows of opportunity in early life when a child’s brain is exquisitely primed to receive sensory input in order to develop more advanced neural systems.”

A mother’s brain... sensitization.

Doula and Kangaroula

BIRTH

D O U L A  and K A N G A R O U L A

'previous 1000 minutes'

DOULA protects OXYTOCIN during labour.

KANGAROULA protects OXYTOCIN after birth.

BIRTH

S S C

Breastfeeding behaviour wiring

OXYTOCIN

W I R E  M O T H E R
Breastfeeding behaviour stimulates OXYTOCIN release in the hypothalamus, which may result in the activation of the dopaminergic reward pathway leading to behavioural reinforcement.

Key biological systems that contribute to maternal caregiving behaviour include the oxytocinergic and dopaminergic systems. Dopamine pathways contribute to the processing of infant-related sensory cues leading to a behavioural response.

Neuroanatomical circuits of parenting are essential for normal parenting behaviours. Integrative physiology and brain imaging of human parent-infant relationships provide valuable insights into the neurobiology of empathy and parenting.

Conclusions and critical summary (Swain et al., 2007):
... there is considerable overlap in the brain structures associated with these neural mechanisms... functional interactions among the circuits.

<table>
<thead>
<tr>
<th>HEALTH</th>
<th>DISEASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESILIENCE</td>
<td>VULNERABILITY</td>
</tr>
<tr>
<td>WELL-BEING</td>
<td>SUSCEPTIBILITY</td>
</tr>
</tbody>
</table>

DOULA and KANGAROULA

OXYTOCIN

Protect OXYTOCIN
Before and after BIRTH

~1000 min
+1000 min
1000 days

BIRTH

SSC

ON-GOING

SSC

WIRE TOGETHER

Neurodevelopmental Approach to
Breastfeeding the Neonate

DUAL INGESTION SYSTEMS

Alberts:
SUCKLING versus FEEDING

Review Article:
Evolution and Development of Dual Ingestion Systems in Mammals: Notes on a New Thesis and Its Clinical Implications

Jeffrey R. Alberts and Rita H. Pickler
**DUAL INGESTION SYSTEMS**


Jeffrey R. Alberts* and Rita H. Pickles†

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13
**DUAL INGESTION SYSTEMS**

**FEEDING**

<table>
<thead>
<tr>
<th>DISRUPTION</th>
<th>SUCKLING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robust</td>
<td>Very sensitive</td>
</tr>
<tr>
<td>Must have right conditions and stimuli</td>
<td></td>
</tr>
<tr>
<td>Separated and fed by tube from day 2 off life</td>
<td></td>
</tr>
<tr>
<td>Starts to feed normally at 21 days</td>
<td></td>
</tr>
<tr>
<td>If starved for 24 hours, pup at 3 will feed food from floor (Can be maintained by smell and other stimuli)</td>
<td></td>
</tr>
</tbody>
</table>

**FEEDING**

<table>
<thead>
<tr>
<th>Influence of SMELL</th>
<th>None</th>
<th>Totally dependent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulin</td>
<td>Increases weight</td>
<td>No effect</td>
</tr>
<tr>
<td>Gherlin</td>
<td>Increases weight</td>
<td>No effect</td>
</tr>
<tr>
<td>Leptin</td>
<td>Decreases intake</td>
<td>No effect</td>
</tr>
<tr>
<td>Cholecystokinin</td>
<td>Decreases intake</td>
<td>No effect</td>
</tr>
<tr>
<td>Amphetamine</td>
<td>Decreases appetite</td>
<td>Increases suckling</td>
</tr>
<tr>
<td>Serotonin</td>
<td>Agonist improves feeding</td>
<td>Antagonist improves suck</td>
</tr>
<tr>
<td>Satiation</td>
<td>Infant determined</td>
<td>Maternal supply determine</td>
</tr>
</tbody>
</table>

**SUCKLING**

<table>
<thead>
<tr>
<th>Influence of SMELL</th>
<th>None</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Motor mechanism</td>
<td>Chewing – different muscles</td>
<td>Suckling – different circuits</td>
</tr>
</tbody>
</table>

**Motor mechanism**

Influence of SMELL

- None
- Totally dependent

**Influence of Motor mechanism**

- Chewing – different muscles
- Suckling – different circuits

**DISRUPTION**

- Pup-in-a-cup
- Separated and fed by tube
- From day 2 off life
- Starts to feed normally at 21 days
- If starved for 24 hours, pup at 3 will feed food from floor (Can be maintained by smell and other stimuli)

**DISRUPTION**

- Must have right conditions and stimuli
- Separated and fed by tube
- From day 2 off life
- Starts to feed normally at 21 days
- If starved for 24 hours, pup at 3 will feed food from floor (Can be maintained by smell and other stimuli)
Nils’ QUESTIONS … NICU context?

Suckling and Feeding are NOT THE SAME.
Up to 6 months, milk is 7.4% fat, 96% of this is TRIGLYCERIDE.

Dendrification and myelinisation peaks occur at 2 and 6 months, is maximal at one year.

At one year: human milk has less protein, but MORE TRIGLYCERIDE!!!

Up to 6 months, milk is 7.4% fat, but after 12 months it is 10.7%.

Fat and Energy Contents of Expired Human Breast Milk in Premature Babies

Phospholipids are a major component of all biological membranes. Sphingomyelin particularly concentrated in BRAIN, major part of MYELIN.

In phosphoglycerides, glycerol molecule same: two fatty acids esterified.

Phospholipids

TRIGLYCERIDE
Left: glycerol, Right: palmitic acid, oleic acid, alpha-linolenic acid.

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Phospholipids

TRIGLYCERIDE
Left: glycerol, Right: palmitic acid, oleic acid, alpha-linolenic acid.
Association between breastfeeding and intelligence, educational attainment, and income at 30 years of age: a prospective birth cohort study from Brazil

“cherry pick”

<table>
<thead>
<tr>
<th>Breastfeed time</th>
<th>Years school</th>
<th>Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 month</td>
<td>10.9</td>
<td>R$ 1238</td>
</tr>
<tr>
<td>&gt; 6 month</td>
<td>12.1</td>
<td>R$ 1915</td>
</tr>
</tbody>
</table>

Group IQ: 3.76 points higher from breastfeeding

---

BREASTFEEDING AND BREAST MILK INCREASE IQ

POLICY STATEMENT
Breastfeeding and the Use of Human Milk

abstract
Breastfeeding and human milk are the normative standards for infant feeding and nutrition. Given the documented short- and long-term medical and neurodevelopmental advantages of breastfeeding, infant nutrition should be considered a public health issue and not only a lifestyle choice. The American Academy of Pediatrics reaffirms its recommendation of exclusive breastfeeding for about 6 months, followed by continued breastfeeding as complementary foods are introduced, with continuation of breastfeeding for 1 year or longer as mutually desired by mother and infant. Medical contraindications to

PEDIATRICS Volume 129, Number 3, March 2012

BOTTLE FEEDING & FORMULA DECREASE IQ

POLICY STATEMENT
Breastfeeding and the Use of Human Milk

abstract

PEDIATRICS Volume 129, Number 3, March 2012
Be sure the wet nurse has plenty of milk... because if she lacks it she may give the baby milk of a goat or sheep or some other animal, because the child... nourished on animal milk does not have perfect wits like one fed on woman's milk and always looks stupid and vacant and not right in the head.

14th century Tuscan text
Not so much duration, or density of any sleep stage, or number of sleep stage episodes, but, **cycling between quiet sleep and active sleep** is what is important.

This is a healthy sleep pattern
This is a very good cycling pattern
(thanks to Susan Ludington-Hoe)

So in every hour, you would like to see an EEG pattern that shows this

REM Sleep is supposed to be somewhat active, so HR increases and RR is irregular

**SLEEP CYCLING – Separation vs contact**

In separation:
- Dissociated state
- No cycling, chaotic pattern

In SSC:
- Normal cycling
- Non-chaotic pattern
The secretion of Areolar (Montgomery’s) Glands from Lactating Women Elicits Selective, Unconditional Responses in Neonates

“...breast chemosignals activate oral activity on the nipple that releases a cascade of behavioral, neural, neuroendocrine and endocrine processes in the newborn and the mother.”

Doucet 2009

"In early ontogeny the sleeping brain may thus remain sentient of an organism’s odor environment."

Doucet 2009

A skin-to-skin contact session SHOULD NOT be less than one hour or 90 minutes!
How often should a neonate feed?

- Feeding frequency
- Sleep cycles

**Brain Wiring**

- CNS: cortical / subcortical (also to PNS)
- ANS: emotional / limbic brain (and ENS)
- CNS: myelinated vagus (NA)
- ANS: unmyelinated vagus (DMC) 
- ENS: subdiaphragmatic
- ENS: submucous plexus
- Myenteric plexus

**Enteric Nervous System!!**

The digestive system is endowed with its own, local nervous system referred to as the enteric or intrinsic nervous system.

The magnitude and complexity of the enteric nervous system is immense - it contains as many neurons as the spinal cord.

**CEPHALIC PHASE**

**GASTRIC PHASE**

**INTESTINAL PHASE**

**Feedback Loops**

- CNS
- ANS
- ENS
- Internal Somatic environment

- CCK
- pH

**The Gut**

- Duodenum
- Jejunum
- Ileum
- Liver
- Gallbladder
- Pancreas
- Large intestine (colon)
- Appendix
- Stomach
- Intestine (small intestine)
- Rectum
- Anus

Figure 2: Example of gastric pH model, in hours: 0-12 (1) fasting, (2) after breakfast (3) after lunch (4) after dinner.
Fetal stomach appears 4 weeks GA. By 11 weeks, wall capable of muscular contraction.

"Patterns of antropyloric motility in fed healthy preterm infants"

... the neuroregulatory mechanisms responsible for the coordination of antropyloric motility and gastric emptying are well developed by 30 weeks of PMA.

**Hassan 2002**

**Hydrochloric acid** important for activation of pepsinogen, inactivation of microorganisms such as bacteria.

**Pepsinogen** activated by acid into active pepsin, responsible for the stomach’s ability to initiate digestion of proteins.

**Chymosin** an enzyme whose role is to curdle or coagulate milk in the stomach, a process of considerable importance in the very young animal.

**Chymosin** makes the milk into "cheese" halfway between liquid and solid stomach empties in 60 minutes

**CEPHALIC PHASE**

**GASTRIC PHASE**

**INTESTINAL PHASE**

**FEEDBACK LOOPS**

EVIDENCE FOR FEEDING FREQUENCY

**Edmond 2006**

**Optimal feeding of low-birth-weight infants**

**TECHNICAL REVIEW**

**World Health Organization**

Findings of the review

**What to feed**

**Breastfeeding or mother’s own expressed milk.** There is strong and consistent evidence that feeding mother’s own milk to pre-term infants is associated with a lower incidence of infections and necrotizing enterocolitis and improved neurodevelopmental outcome as compared with formula feeding. Feeding unsupplemented mother’s own milk to pre-term infants <1500 g resulted in slower weight and length gains, but the implications of this slower growth are unclear and there is not enough evidence to assess if it increased the risk of malnutrition. Long-term beneficial effects of breastfeeding on blood pressure, serum lipid profile or pro-insulin levels have also been reported for pre-term infants. There are limited data on most outcomes in term LBW infants; the available data suggest that improved infection and neurodevelopmental outcomes associated with feeding mother’s milk in pre-term infants are also seen in this group.

**Breastfeeding and mother’s milk: Strong and consistent evidence**
Cup feeding versus bottle feeding:
Cup feeding higher breastfeeding greater stability

Only case series ... Insufficient evidence
No mention of stomach capacity.

Key question:
What is the stomach volume of the neonate ???

Recommendations
The policy statements from international and national organisations were limited either owing to a paucity of evidence or to the need for further research. Available evidence, both observational and experimental, is inadequate for guiding the development of well-informed recommendations on infant feeding patterns. In the absence of clear evidence, practical options and individual expertise should be employed to individualise infant feeding patterns within a health-care setting.

EVIDENCE FOR STOMACH CAPACITY ????

Assumption: 3kg baby requiring 160 ml/kg/day
Daily requirement = 480ml

Optimal feeding of low-birth-weight infants
TECHNICAL REVIEW

Edmond 2006

0 10 20 30 40 50 60 70 80
volume ingested

0 1 1.5 2 2.5 3 3.5 4
feeding frequency

Assumption: 3kg baby requiring 160 ml/kg/day
daily requirement = 480ml

Standard CARE: 3-hourly schedule

Ontogeny of gastric emptying patterns in the human fetus
Sase 2005

Edmond, MSc (epidemiology), PhD
London School of Hygiene and Tropical Medicine, London, UK

Ralf Rhode, MD, PhD
Department of Child and Development, WHO
"Growth of the Fetal Stomach in Normal Pregnancies."

**BRADSHAW formula**

Formula for calculation of stomach capacity (Charles Bradshaw, UCT)

Assumptions: the stomach can be approximated by dividing into three sections, namely an ellipsoidal hemisphere, an ellipsoidal cylinder, and a skewed ellipsoidal cone.

Variables: \( a = \) anteroposterior radius, \( t = \) transverse radius, \( l = \) length stomach

Relations: the height of the cone and the hemisphere are both the same as \( a \).

Ellipsoid = \( \frac{4}{3} \pi r_1 r_2 r_3 = \frac{4}{3} \pi a^2 t \)

therefore volume of hemisphere = \( \frac{2}{3} \pi a^2 t \)

Cylinder = Area of base \( \times \) height = \( \pi a t(1-2a) \)

Skewed cone = \( \frac{1}{3} \) base \( \times \) height = \( \frac{1}{3} \pi a t(1-2a) \)

Total volume = \( \frac{2}{3} \pi a^2 t + \pi a t(1-2a) + \frac{1}{3} \pi a t^2 \)

\( = \pi a t(l-a) \)

Goldstein and Sase data:
Stomach capacity at term 10 - 15 ml

45 MIN CYCLES ( 32 cycles/day)
12 ML PER CYCLE = 384 ml.

**Newborn stomach volume.**

Gastric volumes at birth Correlated with gastric pH, gastrin and somatostatin →

"fetus drinks 10 ml portions of amniotic fluid ...."

Widstrom 1988

Only recent study located:
“Autopsy” capacity was determined in Indian post-mortem studies

“An Autopsy Study of Relationship between Perinatal Stomach Capacity and Birth Weight.”

100 autopsies (63 SB, 37 ENND)
Tied at cardia and pylorus, filled with water, emptied & measured, repeated,
"... obliteration of the gastric curvatures"
"due care to minimize stretch artifacts"

Naveed 1992
Infants above 2500g only:

<table>
<thead>
<tr>
<th>Category</th>
<th>Ave</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stillborn (n 11)</td>
<td>19.6 ml</td>
<td>(10-35)</td>
</tr>
<tr>
<td>Early death (n 9)</td>
<td>17.8 ml</td>
<td>(10-25)</td>
</tr>
<tr>
<td>All cases (n 20)</td>
<td>18.8 ml</td>
<td></td>
</tr>
</tbody>
</table>

Naveed 1992

KERNESUK 1997 (Russian)

Postmortem: in situ measures
(applied Bradshaw formula)

<table>
<thead>
<tr>
<th>Category</th>
<th>Ave</th>
</tr>
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<tbody>
<tr>
<td>Newborn (n 11)</td>
<td>15 ml</td>
</tr>
<tr>
<td>2 months (n 11)</td>
<td>35 ml</td>
</tr>
<tr>
<td>2-4 m (n 10)</td>
<td>50 ml</td>
</tr>
<tr>
<td>4-6 m (n 8)</td>
<td>100 ml</td>
</tr>
</tbody>
</table>

Known references with data:
Scammon and Doyle 1920

"Observations of the capacity of the stomach in the first ten days of post natal life."

Zuccarelli’s method: stomach filled at autopsy to "a pressure of between 15 and 20 centimeters of water"

Scammon 1920

"An Autopsy Study of Relationship between Perinatal Stomach Capacity and Birth Weight."

"Observations of the capacity of the stomach in the first ten days of post natal life."

Anatomic capacity was determined in post-mortem studies
Main data set → Alliot 1905 (n 25)
Scammon own cases ? (n 13)

30 – 35 ml at birth – almost regardless of birth weight

Scammon 1920

Zangen S et al
Rapid maturation of gastric relaxation in newborns

Pressures (mmHg)
Balloon inflates to 15 ml no increase
functional capacity

Zangen S et al
Rapid maturation of gastric relaxation in newborns

Pressures (mmHg)
Balloon inflates to 15 ml no increase
20 ml pressure OK
physiological capacity...
EVIDENCE: (NBn 111009)

<table>
<thead>
<tr>
<th>Author</th>
<th>Capacity</th>
<th>Note</th>
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<tbody>
<tr>
<td>Sase</td>
<td>10-15 ml</td>
<td>Live, term fetus</td>
</tr>
<tr>
<td>Goldstein</td>
<td>10-15 ml</td>
<td>Live, term fetus</td>
</tr>
<tr>
<td>Widstrom</td>
<td>10 mls</td>
<td>Live, newborn</td>
</tr>
<tr>
<td>Zangen</td>
<td>20 mls</td>
<td>Live, (pressure)</td>
</tr>
<tr>
<td>Naveed</td>
<td>20 mls</td>
<td>Autopsy (SB)</td>
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<tr>
<td></td>
<td>20 mls</td>
<td>Autopsy (ENND)</td>
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<tr>
<td>Kernessuk</td>
<td>15 mls</td>
<td>Autopsy (in situ)</td>
</tr>
<tr>
<td>Scammon</td>
<td>30-35 ml</td>
<td>Autopsy (water pressure)</td>
</tr>
</tbody>
</table>

PROPOSAL:

The CAPACITY of a week old baby’s stomach is approx **20 ml**.

**PROPOAL:**

The FEEDING FREQUENCY of the NEONATE is approx **60 min**.

**BRAIN CYCLING**

CEPHALIC PHASE  
GASTRIC PHASE  
INTESTINAL PHASE  

REM  
NR1  
NR2  
NR3  
NR4  

STOMACH FILLING & EMPTYING

Assumption: 3kg baby, requiring 160 ml/kg/day  
daily requirement = 480ml

FUNCTIONAL CAPACITY  
PHYSIOLOGICAL CAPACITY  
RECEPTIVE CAPACITY of stomach  
INGESTIVE CAPACITY of BABY
Normal physiology of the Enteric Nervous System

The “niche” (occupation) of a neonate (Alberts)

BOND → FEED  PLAY → FEED
SLEEP → SLEEP

“Small and frequent feeds, according to the sleep cycle”

Nil’s QUESTIONS … NICU context?

FEEDING  SUCKLING

<table>
<thead>
<tr>
<th>Influence of SMELL</th>
<th>None</th>
<th>Totally dependent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor mechanism</td>
<td>Chewing – different muscles</td>
<td>Suckling – different circuits</td>
</tr>
<tr>
<td>INSULIN</td>
<td>Increases weight</td>
<td>No effect</td>
</tr>
<tr>
<td>GHRELIN</td>
<td>Increases weight</td>
<td>No effect</td>
</tr>
<tr>
<td>LEPTIN</td>
<td>Decreases intake</td>
<td>No effect</td>
</tr>
<tr>
<td>CHOLECYSTOKININ</td>
<td>Decreases intake</td>
<td>No effect</td>
</tr>
<tr>
<td>AMPHETAMINE</td>
<td>Decreases appetite</td>
<td>Increases suckling</td>
</tr>
<tr>
<td>SEROTONIN</td>
<td>Agonist improves feeding</td>
<td>Antagonist improves suck</td>
</tr>
<tr>
<td>SAFETY</td>
<td>Infant determined</td>
<td>Maternal supply determined</td>
</tr>
</tbody>
</table>

Current dogma: THE BABY KNOWS WHEN IT HAS HAD ENOUGH!

PROBABLY NOT!!

WHAT IS THE STOMACH VOLUME OF THE PREMATURE??

Assume low resilience

Assume proportionality →

Figure 3. Mean ± 2 SD of the longitudinal (open circles), the transverse (solid circles), and the anteroposterior (open squares) diameters of the stomach against the gestational age, demonstrating linear relationships.
The CAPACITY of a low birthweight prem from 20ml / 3000g

\[ = 0.007 \times BWt (g) \]

1kg x 0.007 = 7mls
2kg x 0.007 = 14mls

75 ml per feeding ... ?? ASSUMPTION

IMMATURE ????
OR
OVERWHELMED !!!

... many aspects of gastrointestinal motility are immature in the neonate.

Zangen S et al
Rapid maturation of gastric relaxation in newborns

A balloon in stomach can fill to 76 mls
What does the stomach - without a balloon - do to 76 mls?

REFLUX !!!

GER

Dr W Sears

Clues to GER

• Sudden outbursts of crying
• Awakens in pain
• Related to feedings
• Not easily comforted
  "I know baby hurts"
• Sour burps, throaty noises
• Best when upright
"Feed intolerance" … … or VOLUME intolerance?

Amylin peptide is increased in preterm neonates with feed intolerance

V R Karamkonda, A Deroukhshar, C Bruce, R Coombs, R Frenzen, A-P T Mayer

HYPOGLYCAEMIA
A babies stomach empties in 60 minutes.
Blood sugar may fall ...
after 90 minutes ...
Options?

Mitchell 2001
Kerstin Uvnäs-Moberg
**METABOLIC ADAPTATION**

SSC started in the first 20 minutes after birth

**SSC Cot**

<table>
<thead>
<tr>
<th>Blood glucose (1 hr)</th>
<th>3.17</th>
<th>2.56</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base excess drop</td>
<td>3.4</td>
<td>1.8</td>
</tr>
</tbody>
</table>

(Christenson 1992)

---

**The Neuroscience of Birth & Breastfeeding**

**ENVIRONMENT**

WHAT IS THE EFFECT OF MATERNAL ABSENCE ON...

**GENETIC VARIANTS**

**STABILITY**

**MAL ADAPTATION**

**IMMUNITY**

**GUT FUNCTION**

**MICROBIOTA**

**HOSPITAL AQUIRED INFECTION**

**DOHAD**

**EPIGENETICS**

**GENE X ENVIRONMENT**

**NEUROENDOCRINE BEHAVIOUR**

**ATTACHMENT**

**SLEEP PHYSIOLOGY**

**LONG TERM FOLLOW-UP**

---

**Gastrointestinal function development and microbiota**

Delivery mode shapes the acquisition and structure of the initial microbiota across multiple body habitats in newborns

Gut microbial colonisation in premature neonates predicts neonatal sepsis

The “Perfect Storm” for Type 1 Diabetes

The Complex Interplay Between Intestinal Microbiota, Gut Permeability, and Mucosal Immunity
The Neuroscience of Birth & Breastfeeding

The DNA
EPIGENETICS
BEHAVIOUR
EPIDEMIOLOGY
EVOLUTIONARY BIOLOGY
ENVIRONMENT
ADAPTATION
EXPERIENCE
REPRODUCTIVE FITNESS

Gastrointestinal function development and microbiota

The "Perfect Storm" for Type 1 Diabetes
The Complex interplay between intestinal microbiota, gut permeability, and mucosal immunity

METABOLISM

Approximate GLUCOSE

PSNS (vagal) → PSNS (vagal)

SYMPATHETIC → STRESS

4 HOURLY MILK feed

LACTOSE
GLYCOGEN
FAT

METABOLISM

EXPECTED

UNEXPECTED

HEALTH
DISEASE

PSNS (vagal)

SYMPATHETIC → STRESS

Approximate GLUCOSE

LACTOSE
GLYCOGEN
FAT

4 HOURLY ALLOSTATIC STATE

METABOLISM

Weight gain 1st week:
predicts OBESITY at 30 years

Large volume feeds: stretched stomach = doubled absorptive capacity as adult

Weight gain 1st week:

Importance → Programming - early life chronic disease
Gastric overfilling syndrome?

Nils’ QUESTIONS ... NICU context?

Nils’ QUESTIONS ... full term?
Baby weight; freq; req’d size → actual
2kg baby: 4hrly
~ 320 ml/6 = 53 ml → 14 ml
1.5 baby: 3hrly
~ 240 ml/8 = 30 ml → 10 ml
1.0 baby: 2hrly
~ 160 ml/12 = 13 ml → 7 ml

Standardised from 20ml capacity for 3kg baby (x 0.007)

Nils’ QUESTIONS … full term?

SUCKLING IS COMPETENT
FEEDING IS IMMATURE

Elevated activity sustained over time, or severe
→ changes the “set points” for homeostasis (e.g. increasing blood pressure, change in cholesterol level)

Recommendations

1. Policy statements from international or national organisations have limited utility if insufficient evidence is considered for feeding in specific neonatal groups. Strength of evidence: Class IIa, Level of evidence: 2b.


3. Only case series information is available. Strength of evidence: Class IV, Level of evidence: 5.


No mention of stomach capacity.

Kerena Edmond, MBBS, MRCOG (Obstetrics and Gynaecology), FHEd London School of Tropical Medicine.

Preterm premature and immature infants

Elevated activity sustained over time, or severe
→ changes the "set points" for homeostasis (e.g. increasing blood pressure, change in cholesterol level)

Only case series ...
Insufficient evidence
No mention of stomach capacity.
Gastric overfilling syndrome?

**Excessive volumes**
- reflux, aspiration, colic

**Excessive time interval**
- hypoglycaemia

**Adaptations**
- diabetic diathesis, obesity

---

### Developmental Care of the Enteric Nervous System

The "niche" (occupation) of a neonate (pluripotent)

- **BOND** → **FEED**
- **PLAY** → **FEED**
- **SLEEP** → **SLEEP**

"Small and frequent feeds, according to the sleep cycle"

---

### Proposed Management

Babies should be fed **EVERY TIME THEY WAKE!!**

---

### Proposed Management

All babies should be fed at least once an hour!!

---

**Line graph**

- X-axis: Week 0 to Week 4
- Y-axis: Percentage

**Summary**

- **Gastric overfilling syndrome**
- **Excessive volumes**
- **Excessive time interval**
- **Adaptations**

**Clues to GER**

- "I know baby hurts"

**Developmental Care**

- Neonatal sleep cycles
- Feeding patterns

**Proposed Management**

- Feeding every time the baby wakes

---

**Stanley Graven 2006**

- REM
- NR1
- NR2
- NR3
- SWS
- AS (20 mins)
- QS (40 mins)

A normal sleep cycle is **ONE hour.**

**How often should neonates feed?**

- Every time they wake!

---

**Diagrams**

- Stomach illustration
- Graph showing percentage increase over weeks

---

**Table**

- Week 0: 10%
- Week 1: 20%
- Week 2: 30%
- Week 3: 40%
- Week 4: 50%
All babies should be fed at least once an hour!!

The first Milk Ejection Reflex (MER) elicited in < 2 minutes works quickly swallowed 1 minute

Feeding time (max) 3 minutes
Repeat every 1 hour

The "normal" or usual and common breastfeed takes 15 minutes discomfort after burping time 5 minutes

Feeding time 20 min Repeat every 3 hours

3 minute 20ml feeds x 24/d = 72 minutes
20 minute 60ml feeds x 8/d = 160 minutes

SMALL AND FREQUENT FEEDS ARE EFFICIENT !!!
FEWER NURSES NEEDED !!!

The calculated daily requirement for a 3kg baby can be given without increase in pressure .... → MINIMAL RISK

20 ml x 24 feeds = 480ml / day

PARENTS CAN DO SAFELY!

All babies should be fed at least once an hour!!
Infant feeding frequency: Proposal based on available evidence and neuroscience

“Small and frequent feeds, adjusted to the sleep cycle”

How often should a neonate feed? A neonate sleep?

Infant: sleep cycles begin to block on diurnal rhythms

Infant sleep cycling and synchronicity with maternal sleep ensure development.

Infant: sleep cycles begin to block on diurnal rhythms

Mother-infant synchrony

… at 12 weeks (circadian) Thomas 2014

START at 3 months

Can be “adult-like” at 6 months.
Infant sleep cycling and synchronicity with maternal sleep ensure development.

**SMELL (& SKIN)**

modulates state organisation
elicits emotional behaviours

activates pre-feeding actions
anticipatory digestive physiology
regulates pace of ingestive behaviour

Schaal 2004

**SMELL (& SKIN) → “SLEEP-FEED CYCLING”**

modulates state organisation
elicits emotional behaviours

activates pre-feeding actions
anticipatory digestive physiology
regulates pace of ingestive behaviour

Schaal 2004

“Scientific foundation” ... a synthesis

ZERO SEPARATION
THE NEUROSCIENCE OF SKIN-TO-SKIN CONTACT AND BREASTFEEDING

ARE THE SAME!

www.ninobirth.org
www.skintoskincontact.com

SUMMARY!!

SKIN-TO-SKIN (Regulation)
SLEEP (Brain)
FEEDING (Stomach)

LOVE! ("mind")

www.facebook.com/ninobirth
Nelson Mandela

... in describing the measure of a nation, he has argued that

“There can be no keener revelation of a society’s soul than the way in which it treats its children.”